

AJAX-BASED LINKAGE OF DATABASES FOR LOCATION-BASED-SERVICES: THE ONLINE-CAMPUSGIS OF THE UNIVERSITY OF COLOGNE

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ABSTRACT:

This paper presents recent improvements of the CampusGIS of the University of Cologne (<http://www.campusgis.de>) which is designed, developed and established by the GIS & Remote Sensing research group at the Department of Geography at the University of Cologne. The overall task of the CampusGIS is to provide general and spatial campus information, e. g. visualization, advanced search functions, orientation, routing, navigation, and facility management. To meet these requirements, it was essential to connect several existing relational database systems of the University of Cologne with spatial data within an online GIS environment. The overall design approach is based on a linkage of these DBMS with spatial data to provide location-based services (LBS). Therefore, several objects and attributes of the CampusGIS geo database were surveyed using Differential GPS and total station. In addition to the major developments, a 3D model of the buildings, starting at a level-of-detail (LOD) 1, improves the visualization. Thus, the CampusGIS - as an AJAX-based application for online information - is able to supply data concerning university staff, lectures, institutions, buildings, facilities etc.

KURZFASSUNG:

Dieser Beitrag stellt die neuesten Entwicklungen des CampusGIS der Universität zu Köln (<http://www.campusgis.de>) dar. Ziel der Projektgruppe, die aus der Arbeitsgruppe GIS & Fernerkundung des Geographischen Instituts hervorgeht, ist es, dem potentiellen Nutzer allgemeine und räumliche Informationen zum Campus, wie z. B. erweiterte Suchfunktionen, Orientierungshilfen, Routing- und Navigationsanwendungen anzubieten. Um diesen Anforderungen gerecht zu werden, war es entscheidend, verschiedene vorhandene relationale Datenbanksysteme (DBMS) der Universität mit räumlichen Daten in einem WebGIS zu verknüpfen und somit ortsbezogene Dienste (location-based services, LBS) bereitzustellen. Folglich wurden für die CampusGIS-Geodatenbank Objekte und Attribute mittels DGPS und Tachymeter erhoben. Zusätzlich verbessert ein 3D Modell, zunächst als LOD 1, die Visualisierung. Somit ermöglicht das CampusGIS - als eine AJAX-basierte Web-Anwendung - die Bereitstellung von Informationen über den Lehrbetrieb, die Beschäftigten, Institute, Gebäude und Einrichtungen.

1 INTRODUCTION

The first release of the CampusGIS was established in the year 2005 and operational in early 2006. As the web-technology, -design and -development show tremendous changes in the last years the development of the system result in a general reorganisation of the former used technologies and in a broad site relaunch to ensure a better interaction design. In contrast to the first release showing a classical HTML- and JavaScript-structure with PHP-scripts connecting the databases (Baaser et al. 2006a), the intern communication is now based on AJAX (Asynchronous JavaScript + XML) that allows a fast "Web 2.0"-look and feel (O'Reilly 2005).

2 THE GEODATABASE

The CampusGIS is composed of different datasets which are stored in a relational file geodatabase: (i) authoritative topographic geo data, (ii) surveyed data, (iii) alphanumeric data, (iv) CAD-drawings, and (v) airborne laser scan data.

2.1 The digital base map

The digital base map of the system is derived by selected and grouped objects of the ATKIS-dataset (Authoritative

topographic cartographic information system of the Federal Republic of Germany). Footpaths, buildings of the university and building-entrances are digitized from digital ortho images and DGK5 (Basic Map of Germany in a scale of 1 : 5,000) or surveyed using Differential Global Positioning Systems (DGPS) and total station. Dedication of the total station allows the spatial localization in all three dimensions using distance measurement of a basing point. Readings are taken with optical, electronic or classical total station.

Postal addresses of university buildings are stored in a MySQL-database administrated by the Regional Computing Centre of the university (RRZK). Data about staff and institutions is stored in a Content Management System (CMS) named *uk-online* (Uniflash 2004).

The GIS data is stored in ESRI *shapefile* format as this file format is common for an ArcIMS application based on an AXL file. To evaluate the topology, the data has also been converted into *featureclasses* of a *file geodatabase*. This data format also is needed for the future version of CampusGIS that will be based on ArcGIS Server (see chapter 5). Besides the correction of digitising errors, e. g. so called *over-* and *undershots*, an appropriate linkage of the ATKIS- with the surveyed data needed to be implemented. Particularly with considerations to

the intended routing and navigation application, vertices were added to the junctions that connect the different object groups among each other. In contrast, crossovers and underbridges did not get a node.

2.2 Indoor information

To improve the service for students and visitors of the university and for administrative management floor maps and indoor information are included with Hyperlinks to the specific websites of the university. These raster images (*.jpg or *.pdf files) are opened in a new browser window.

Two-dimensional CAD-Drawings of the floors of some buildings were implemented into the password protected CampusGIS version for internal use (see Figure 1). These CAD-data are georeferenced and visible on a large scale. According to custom points, lines and polygons of the drawing are displayed in different colors for different layers.

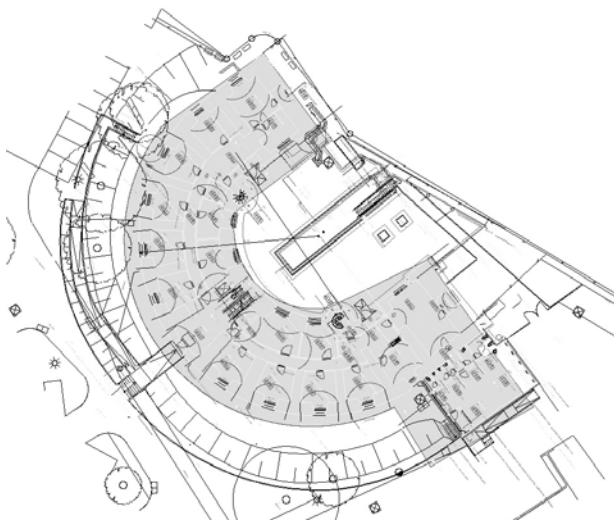


Figure 1. Example of a CAD-drawing implemented in the password protected CampusGIS environment

2.3 Laser scan data

For 3D city modelling the heights of the university buildings have been calculated using laser scan data from digital elevation models (DEM). There are two DEM surveyed and offered by the Land Survey Office North Rhine-Westphalia which are used within the CampusGIS: The *digital terrain model* (DTM, DGM5L) maps the surface of the natural landscape. The *digital surface model* (DSM, DOM5L) represents the outmost cover of a laser scan aerial flight which thus displays vegetation- and building surface (BILL and ZEHNER 2001). To get the building height the altitude difference is calculated by subtracting the DGM5L from the DOM5L. The data processing has been made in ESRI's ArcGIS.

3 REDESIGN, RELAUNCH AND ENHANCEMENTS OF THE CAMPUSGIS

3.1 Web technology

Based on the software ArcIMS, the Internet Map Server of ESRI, the latest version of the CampusGIS runs on an Apache web server. This contribution uses HTTP to reply the requests of the client. The application program interface (API), in this

case the Java Virtual Machine integrates application functionalities into the server. Thus, these functions do not have to run on client-side. The servlet engine (Jakarta Tomcat) is connected to the web server as an interface between the Java Virtual Machine and the web server. It is a platform independent program module which also runs on server side.

Various employments in world wide web technologies, design and demands on the CampusGIS caused a wide site relaunch: to answer database requests without reloading the website with its map and to remove bugs and redundancies occurred during development all program scripts are adapted and in doing so the internal communication is changed over to AJAX. AJAX is the abbreviation for Asynchronous JavaScript + XML and its general advantages are (i) the use of web standards like XHTML and CSS, (ii) the interaction and dynamic display using the Document Object Model and (iii) the asynchronous query using XMLHttpRequest (Garret 2005). Due to these advantages, AJAX - "a key component of Web 2.0 applications" (O'Reilly 2005) - allows the adjustment of the map extent accordingly to the screen resolution and the browser window dimension during run-time.

Figure 2 describes the methodological approach which is used to realize the CampusGIS with AJAX: While in former versions staff- and institution-requests were sent to *uk-online* by PHP and a building-request was sent to the MySQL-database of the RRZK via PHP, too (Baaser et al. 2006b) currently the CampusGIS passes on the use of PHP as far as possible.

Concerning the functionality, the overall system architecture could be divided in two major parts: (i) Advanced search and (ii) building information requests, which are briefly described in the following sections: (i) the user sends a request to the CampusGIS system server. With that request, a search for persons or institutions is sent to *uk-online* by URL and SQL-GET-Query. The buildings request is directly sent to the MySQL address database. The XML-reply of the database contains information about the requested object and an object identification number (ID) assigned by the administration of the university. This information is stored in a global array. With the building-ID as well-defined key a PHP-request for the building's postal address is sent to the MySQL database of the university's administration. With this selection, ArcIMS is able to create a map from the shapefiles with the searched object in its center by using AXL. This map is stored temporary as a bitmap (*.jpg) file. Additional information stored in the global array is reported next to the map. In detail it contains the searched string, the postal and the web address. Staff information is added by the institution, the phone number and an icon for directly open an e-mail-form included the e-mail-address. Additionally a second icon is linked to the *uk-online* personal website with further information.

Building information requests occur by point-and-click on a building. CampusGIS queries the address database using AJAX: the client sends the screen coordinates to the ArcIMS-Apache-server to get the appropriate building-ID and store it in the global output array in conjunction with the envelope. Afterwards the postal address is selected from the MySQL-database of the university's administration and assigned to the global array. This request is done by PHP. The advantage of this approach is that the database login information is not accessible in the source code of the website. In a final step, a website is generated by using HTML, CSS and JavaScript, which includes the map and alphanumerical information about the request. This HTML-page is sent back to the client as a reply.

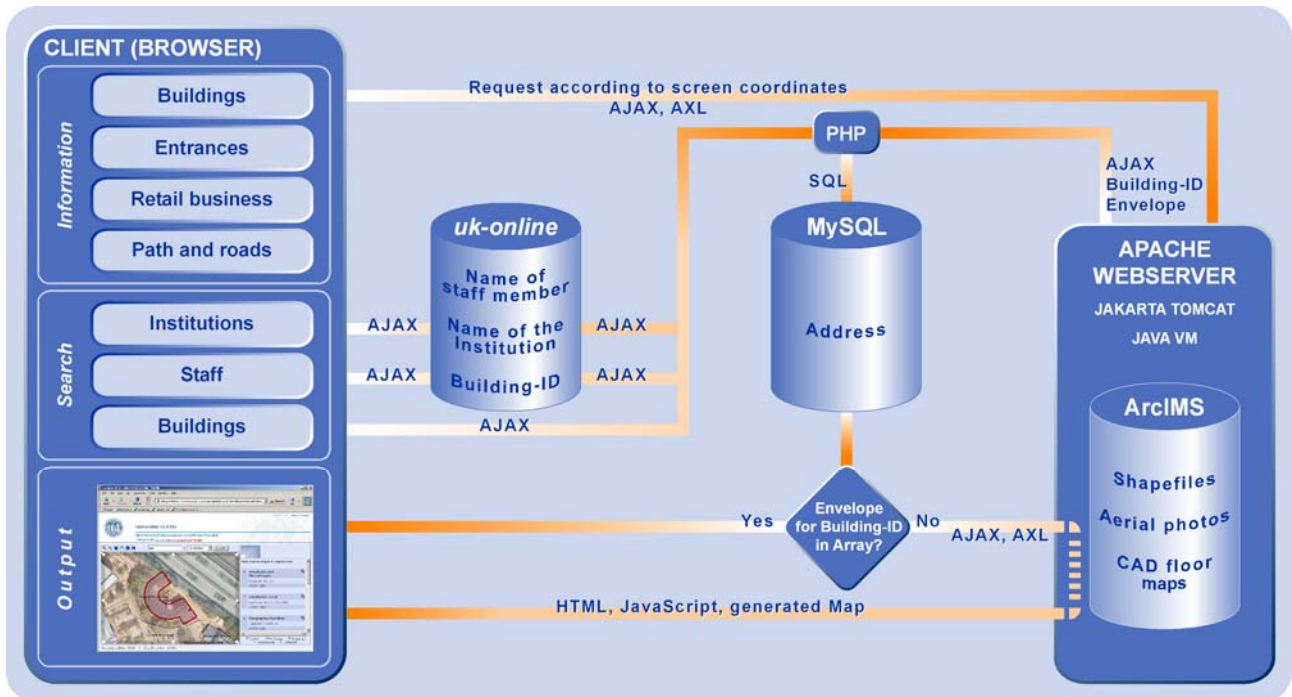


Figure 2. AJAX system architecture

For parsing the XML-response a JavaScript-Parser is integrated and so a standardized interface for linking other databases is created. The JavaScript-DOM-Parser is used for the syntactic analysis of the XML-reply. The Document Object Model (DOM) is an application programming interface that allows access to HTML- or XML-documents. Its classes, methods and attributes, developed and defined by the W3C (World Wide Web Consortium), are platform- and language independent. In this manner a standard interface for further database connections is included.

To summarize, the CampusGIS is designed and programmed based on a modular software development approach. That enables the enlargement with further applications without reprogramming the complete system. In general, this means that the implemented GIS functionalities are accessible stand-alone and additional tools can be developed and integrated without changing the overall development framework of the system.

3.2 Web design

In the end of 2006 the University of Cologne introduces its corporate design. Any visual presentation of every institution should govern the use of these consistent requirements. The external appearance is to be noticed uniform and distinctively (Universität zu Köln 2006). With this presetting CampusGIS gets a new web design that first of all is indicated by the blue background color and the raised official seal of the university at the upper right side (see Figure 3). The functionalities of the CampusGIS are obtained (Baaser et al. 2006a).

3.3 Routing

To meet the requirements of being a comprehensive online GIS, the future version is developed based on ArcGIS Server: The routing button opens a form as an interaction tool for the user: by selecting a starting point and a destination of a routing request, CampusGIS calculates the shortest path for cars and

persons using public transport, for pedestrians as well as for handicapped persons. This tool is realized by using a knowledge based decision support algorithm coupled to the ESRI Network Analyst (ESRI 2007). In a first analysis step, the routing tool of the CampusGIS creates a vector result by using the ATKIS-line data and the footpath data. It calculates the temporary shortest path between two nodes to generate the route from the starting point to the destination step by step. This route is drawn into the CampusGIS map that is included into the HTML-page. This CampusGIS function can be used by different user groups. By using the routing tool, the user is able to receive a personalized routing. For example, if a handicapped person using a wheelchair starts the routing, the routing algorithm uses additional footpath parameters like inclination, surface and the ability to use ramps or lifts instead of stairs.



Figure 3. Screenshot of the Online-CampusGIS with reply of an institution-request

In this case, the existence of stairs acts as a knocked-out criterion what means that the algorithm calculates another direction without this barrier.

The additional use of the collected attribute data (walk time, ramps, doors, building entrances, etc.) within the decision algorithm appears in the advanced routing output. The resulting walkway (line vector) represents the shortest path from the starting point to the destination with regard to the requested time, geographical position and personal conditions of the user.

By using the campus WLAN the applications provides also location based services (LBS). Therefore the CampusGIS gets a separate GUI for mobile devices. In a next step the routing application will be upgraded to navigation. As the routing application needs the input of start and destination points by the user which thus has to be orientated, the planned navigation application gets the location of the user by GPS. Also the visualisation of a navigation application will be improved by 3D buildings.

3.4 Implementation of a 3D city model

A 3D campus model was produced for visualization and facility management within the CampusGIS project. Because of data availability and present software a half automatic way of 3D modeling was used which is briefly described in the following section.

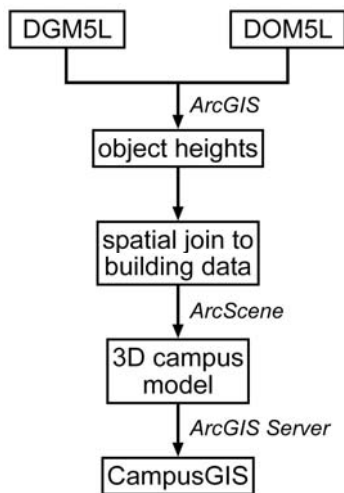


Figure 4. Workflow: 3D model generation

After processing the digital elevation models the average height for every building was added as an attribute to the building data, see Figure 4. In ESRI's ArcScene this data could be extruded by the calculated value and stored as 3D data.

4 RESULTS

4.1 CampusGIS

The web-based CampusGIS of the University of Cologne serves several GIS-functions (see Figure 3). During the development, the focus was set on creating a user friendly, easy to use, comprehensive online GIS. Therefore, there are only these functions implemented which should be well-known by GIS-uninitiated persons, e. g. from web-portals with routing services

like *Mapquest* (Baaser et al. 2006a). That includes user interactions with the map: Zooming in and out, panning, getting the full extent and displaying the campus are implemented tools. For retrieving specific information about buildings or search for buildings, staff and institutions the user has to request the information- or search-form. The information tool opens a pull-down menu for the information content specification including buildings, entrances or footpaths. The binocular symbol selection opens the search form for string input and database embedding. The requested object is zoomed, centred and highlighted in the map by using the lens symbol. All of this information is sent from server to client by using AJAX. This guarantees the use of actual web standards like XHTML and CSS, the interaction and dynamic display using the Document Object Model and the asynchronous query using XMLHttpRequest (Garret 2005). Due to these advantages, AJAX adjusts the map extent accordingly to the screen resolution and the browser window dimension during run-time.

The input of a starting and destination point is requested by opening the routing form. CampusGIS calculates the shortest path for the given parameters based on the knowledge based decision support algorithm (see chapter 3.1). The routing result is visualised as a highlighted path on the map. The output section lists additional information about these streets and footpaths.

4.2 CampusGIS 3D

The achievement of the laser scan processing is a 3D block model of the campus (see Figure 5). According to the *Special Interest Group 3D (SIG 3D)* of the *Initiative Geodata Infrastructure North Rhine-Westphalia (GDI NRW)* it is classified as a *level of detail (LOD) 1*.

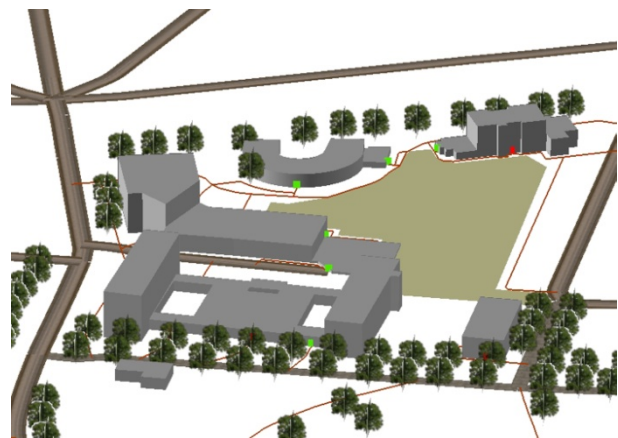


Figure 5. CampusGIS 3D

This 3D model has been added to the CampusGIS and published with ESRI's ArcGIS Server as a globe service for internal testing. Soon the application of the 3D campus model will be available through the internet for all users using ArcGIS Software or ArcGIS Explorer.

5 CONCLUSION AND OUTLOOK

Besides several GIS functions like zooming in, -out, and to full extent, panning, identifying geo objects and searching for buildings, persons, and institutions, particularly the routing application, based on the knowledge based decision support

algorithm is implemented into the CampusGIS. All of this information is linked by using AJAX, thus the system is ready for location-based services. This comprehensive application is enhanced by 3D and indoor building information and appears as an easy to use, user friendly, online GIS.

As already mentioned in chapter 3.3 future versions of CampusGIS will be realized on ESRI's ArcGIS Server. Among others, this will also enable to serve different geoprocessing applications like navigation, 3D visualisation and -routing and -navigation.

With the enlargement of the base map from the campus to the urban area of Cologne there are some more information needed. A city information system with navigation applications is in preparation. It requires data about the public transport including its time schedules. The implementation of further information, e.g. tourist information for sightseeing, accommodations etc. is planned.

In addition to the PC-version of CampusGIS, latest efforts are developing a separate GUI for mobile devices showing high scaled indoor maps. With WLAN access at the campus the applications will offer LBS: On the campus the upgrading with floor maps and indoor information is the most priority objective. The aim is to navigate students to their lecture halls and qualified skilled worker to their object of maintenance. With mobile devices it is possible to get CAD-drawings and other information everywhere.

Data surveyed from a terrestrial laser scanner will be implemented to improve the visualization and orientation for the user. In further steps a higher LOD is planned. A secured version of the CampusGIS with detailed information about the buildings would improve the campus facility management and planning.

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